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THE INDEPENDENT NEWSPAPER & TEST LAB OF DEC COMPUTING

PHOTO: TIM DAVIS

A NEW GRAPHICS POWER COMES TO LIGHT

BY DENIS W. HASKIN

Last year's bicoastal merger of Newton, Mass.-based Stellar Computer and Ardent Computer of Sunnyvale, Calif., to form Stardent Computer hasn't slowed the release of new products from these minisupercomputer developers. While the future of products released by the two original companies is still up in the air, the new company has come out with an exceptional minisupercomputer bearing the Stardent name.

Dubbed the Stardent 3000, this new machine comes in two flavors: the Stardent 3000 Visualization System and the Stardent 3000 Departmental Supercomputer. The new models send a clear message that Stardent has selected Ardent's Mips-based hardware over Stellar's proprietary hardware and suggests the company will favor Stellar's software over Ardent's. Stardent has announced that it will merge the Stellar and Ardent product lines by 1991.

We tested the two-processor version of the visualization model, the Stardent 3020 Visualization System, and were thoroughly impressed. The Stardent 3000 turned in an admirable 39.68 MicroVAX II units of processing (MVUPs) on DR Labs' CPU 2 test suite (Fig. 1).

Stardent's 3000 Visualization Systems and Departmental Supercomputers deliver exceptional images

The Stardent 3000 is a direct descendant of the Ardent Titan II, which is now referred to as the Stardent 1500. Much of this new system is identical to its predecessor, with the exception that the 3000 uses Mips Computer Systems' R3000 RISC chip, whereas the Stardent 1500 uses the R2000.

Unlike other vendors of graphics minisupercomputers, including Silicon Graphics, Stardent employs a graphics processor that uses a limited amount of specialized hardware, relying instead on the power of a vector processor and some help from the Mips R3000. The graphics subsystem consists of one or two boards that are tightly coupled with the CPU and memory subsystems (Fig. 2). The optional second board provides additional frame buffers and rasterizers.

The Stardent 3000 Departmental Supercomputer is the Stardent 3000 Visualization System minus the latter's graphics boards and the display hardware that accompanies them.

The 3000's rasterizers transform an image into pixel data and draw it into the frame buffer. Given the very simple task of displaying an image of a straight line, for example, the rasterizers would first determine which pixels need to be turned on to show that line and then turn on those pixels in the frame buffer.

In addition to their drawing operations (which include Gouraud-shading and Z-buffer hidden-surface removal), the rasterizers also perform pixel fill, movement of rectangular blocks of pixels within the frame buffer, and transfer of pixels from memory to the frame buffer and vice versa.

Z buffering is a method of handling hidden-line and surface removal. The Gouraud technique is used to shade solid objects.

Stardent's single-board graphics subsystem has a frame buffer with 24 color planes, and has two rasterizers. The graphics expansion board adds another 24 planes to the frame buffer, along with two additional rasterizers.

The graphics subsystem has two color modes: full-color and pseudo-color. In full-color mode, the system can display 16 million colors simultaneously. In pseudo-color mode, 256 colors may be simultaneously displayed out of a possible 16 million. Each mode has its own color map.

The subsystem also has four overlay planes for cursors, pop-up menus, and similar graphic elements, as well as three control planes used for color mode selection and double-buffering.

Data is transferred from main memory to the graphics subsystem over a 64-bit DMA channel, with a 32-bit DMA channel serving in the reverse direction.

The graphics expansion board includes a genlock interface, allowing users to make broadcast-quality recordings of the displayed graphics. This board provides both NTSC and PAL genlocking and generates RS-170A- or PAL-compatible video signals.

CPU POWER

The CPU structure of the Stardent 3000 is typical of implementations that make use of the Mips RISC chips: it uses the R3000 integer scalar processor along with an R3010 scalar floating-point processor. Each CPU unit also includes two independent 64KB direct-mapped caches—one for instructions and the other for data—and four-deep write buffers.

The Stardent 3000 is a true multiprocessing system that can have from one to four CPUs (Fig. 3). Each CPU incorporates both a scalar and a vector processor. The scalar processor consists of the Mips R3000 and R3010 running at 32MHz. The vector processor is a proprietary product from Stardent.

The scalar processor handles all integer and almost all floating-point scalar operations, and functions as the scene database traverser during graphics operations. (The vector processor incorporates a scalar floating-point processor, but it is rarely used now that the Mips R3010 floating-point proces-

TEST dr LABS MODEL

We tested a two-processor version of the Stardent 3000 Visualization System, the Stardent 3020, with 64MB of memory, a graphics expansion board and two 760MB disk drives.

Among the target audience of the Stardent 3000 Visualization System are scientific investigators doing interactive simulation of complex systems, such as the computational fluid dynamics used for weather modeling. Such users need substantial CPU power to perform the involved integer and floating-point calculations such applications require, allowing these users to change the parameters of their model and quickly see how those changes affect their results.

To evaluate the Stardent 3000's ability to satisfy this demand for compute power, we ran DR Labs' CPU 2 benchmark suite on the Stardent 3020. CPU 2 measures a system's ability to handle scientific and engineering applications. Its results reflect the raw speed of a CPU, the efficiency of a system's Fortran compiler, and—to a lesser extent—the speed of memory access. The results are not affected by a system's I/O capabilities.

CPU 2 includes integer calculations, single- and double-precision floating-point calculations, and matrix calculations. Individual kernels measure a system's ability to do vector processing, and some kernels measure the improvement achieved by systems with parallelization capabilities.

TEST dr LABS BRIEF

PRODUCT: Stardent 3000

DESCRIPTION: RISC-based multiprocessing and vector processing graphics supercomputer

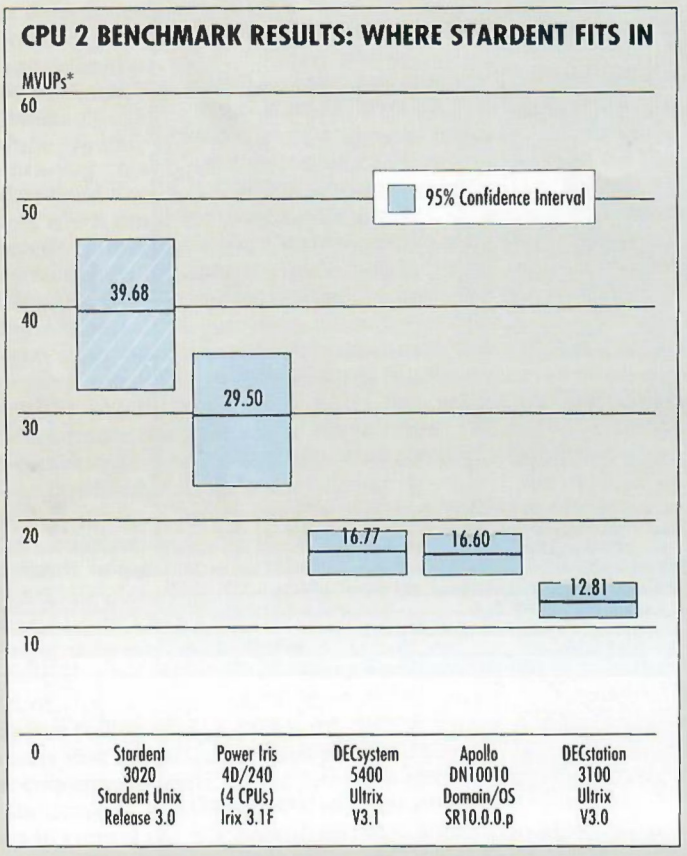
VENDOR: Stardent Computer Inc.
880 W. Maude Ave.
Sunnyvale, CA 94086
(408) 732-0400

TEST CONFIGURATION: Stardent 3020 Visualization System with two CPUs, 64MB of memory, two 760MB disks and expansion graphics board

PRICE AS TESTED: $176,900

PROS: ■Offers high compute performance ■Has automatic vector and parallelizing compilers ■Has multiprocessing Unix ■Supports multithreaded processes ■Offers high-level graphics environment

CONS: ■I/O bandwidth not as high as other minisupercomputers



Statistical Analysis of Benchmarks for Stardent 3020

KERNEL NAME	MICROVAX II TIME (SEC.)	3020 TIME (SEC.)	3020 MVUPs*	PSEUDO MVUPs*	SCALED RESIDUALS
FFTR	83.73	2.58	32.41	31.62	1.86
LAHYDR	85.60	1.33	64.56	58.85	–4.60
LABLE	82.39	1.57	52.46	50.71	–2.67
LATRD1	81.24	2.64	30.83	29.63	2.33
LATRD2	81.84	2.45	33.39	32.81	1.58
LAPDE	81.25	1.29	63.21	58.03	–4.40
LADIFF	74.51	1.66	44.86	44.54	–1.20
LAFSUM	80.58	4.36	18.48	8.99	7.23
LA2DPP	84.57	4.27	19.80	11.79	6.56
LA1DPP	82.35	4.23	19.49	11.15	6.71
LA2DHY	75.75	2.12	35.75	35.53	0.93
LAFIMI	81.33	4.18	19.47	11.12	6.72
LAIMCO	81.88	3.24	25.29	21.68	4.22
LAMAPR	79.33	1.29	61.44	56.92	–4.14
LINPAC	80.02	1.57	51.05	49.64	–2.41
AIRREL	81.53	3.02	27.00	24.31	3.59
DWHET	82.38	0.81	102.01	76.62	–8.81
DOUBLE	76.95	0.80	96.22	74.37	–8.28
EGYPT	78.48	2.64	29.70	28.14	2.69
EGYPTD	83.00	2.63	31.55	30.56	2.11
GAUSS	82.88	2.02	41.08	41.06	–0.38
HANOI	76.52	4.33	17.68	7.21	7.65
NEFF	80.79	0.98	82.51	68.41	–6.87
PHILCO	75.96	1.59	47.70	46.97	–1.78
PRIME	73.21	8.50	8.61	-22.38	14.67
RR2	82.58	2.30	35.84	35.63	0.91
RR3	83.87	2.89	29.03	27.21	2.90
RR4	82.44	4.96	16.63	4.70	8.25
SINGLE	75.02	1.09	68.95	61.42	–5.21
SWHET	77.10	0.99	77.54	66.00	–6.29
ALAM18	85.25	1.43	59.82	55.87	–3.89
GAMSIM	91.77	0.65	142.28	89.39	–11.84
LUDD	86.99	1.17	74.59	64.49	–5.94
LUSD	82.65	1.66	49.82	48.68	–2.19
	Geo. Mean 80.96	Geo. Mean 2.04	Geo. Mean 39.68	Jackknife Value 39.46	

Summary of Statistical Analysis

DR Labs Standard MVUPs*: 39.68
Variance: 17.7752
Standard Deviation: 4.2161
95% Confidence Interval: 32.38 – 46.54

* MVUPs = MicroVAX II units of processing.

FIGURE 1: *The two-processor Stardent 3020 delivered a strong 39.68 MVUPs. The Silicon Graphics Power Iris, a graphics minisupercomputer targeting much the same applications areas as the Stardent, delivered only 29.50 MVUPs with four CPUs.*

sor accompanies the R3000.)

Stardent's vector unit, built with components from Bipolar Integrated Technologies, handles all vector operations. During graphics processing it serves as the geometry engine for the system, performing the requested transformations and other graphics operations.

This vector processor is very similar to the one used in the Stardent 1500, but with a few enhancements: the vector instruction set has been increased somewhat, some restrictions on the use of vector registers have been lifted, and there is now better data communication between the vector and scalar processors.

The vector unit uses a vector register file with four banks of 2,048 64-bit words. The divider, pipelined multiplier and pipelined adder of the vector arithmetic unit operate concurrently. A vector data switch handles all transfers of data between the vector unit and memory. It also handles transfers within the vector unit from the vector register file, to and from the vector arithmetic unit.

Stardent's vector processor can work with vectors of any length that start anywhere in the vector register file.

The Stardent 3000's memory system is closely integrated with the bus structure of the machine. The 3000 can have from one to four memory boards, each populated with 8MB, 16MB or 32MB of error checking and correcting (ECC) memory. Depending on its configuration, the memory system can provide either 8-way or 16-way interleaving.

The 3000 uses two buses to communicate between the memory, CPUs, I/O and graphics subsystem (Fig. 4). Both buses have 32-bit address and 64-bit data paths and operate at 16MHz.

One bus, the R-bus, is dedicated to data transfers from memory to the vector processor. The other bus, known as the S-bus, handles all other transfers.

The I/O subsystem of the 3000 is implemented on a single board and supports all of the I/O functions with the exception of graphics display (it does handle the input devices of the graphics display, including the keyboard, mouse and other devices).

This subsystem uses an internal bus operating at 64MB per second as well as an additional "microbus" that runs at 2MB per second. The primary bus supports two SCSI channels, each of which can support as many as seven SCSI devices, and a VME interface. (The VME bus is optional.)

The microbus supports the keyboard and mouse of the graphics workstation and provides four RS-232-C ports (with full modem control), a parallel interface, regular and thin-wire Ethernet, and a sound generator. Other incidental support components include a clock, timer, and nonvolatile RAM for address and configuration information. The I/O subsystem connects only to the S-bus.

RUNNING ON UNIX

The Stardent 3000 runs a fully multiprocessing, multitasking version of Unix that is totally compatible with AT&T System V release 3 and incorporates extensions from Berkeley 4.3.

Stardent's Unix has been modified to yield greater performance on the 3000's multiple CPUs. It offers fully asynchronous multiprocessing: the operating system runs in parallel on all processors.

In a significant departure from some multiprocessing systems, Stardent's Unix supports single-process, multithread microtasking. That is, a single process is divided into threads, each of which can operate in parallel on multiple processors.

Other features of the operating system include the implementation of a "disk farm" device driver to facilitate disk striping, Streams-based device drivers and application-controlled asynchronous file I/O.

To boost system performance, Stardent has modified the file system by organizing files contiguously, using large read sizes to reduce the number of disk accesses and making substantial use of read-ahead I/O.

Like most Unix implementations, Star-

dent's includes support for the TCP/IP and NFS network protocols, and the company offers optional DECnet emulation. Other DEC compatibility features include strong support for VAX Fortran, an EDT-like text editor and DCL command interface emulator, as well as an ad-hoc collection of LIB$ and SYS$ run-time library routines.

Programming languages currently available on the Stardent 3000 include C and Fortran (a validated Ada compiler is available on the 1500 but has not yet been validated for the 3000). The compilers differ only in their front ends, which compile the source code to an intermediate language. Vectorizing, parallelizing, optimizing and code generation are the same in the two languages. The compilation process includes an instruction scheduler that reorders instructions to improve overlap of floating-point and integer operations and memory access.

The C compiler is based on AT&T System V release 3 C with some extensions from the ANSI C standard. The run-time libraries are based on both System V and BSD libraries. The Fortran used is ANSI Fortran-77 with extensions from VAX Fortran version 3.0, and the compiler accepts many Cray Fortran directives. The Fortran I/O library has also been completely rewritten for improved I/O efficiency.

All of the compilers provide automatic parallelization of code.

The user interface for the Visualization System is Stardent's implementation of the MIT X Window System, termed X+. The Departmental Supercomputer includes the X+ library to allow clients to execute on that node. Most of Stardent's extensions are for the X server and include support for double-buffered windows, true- and pseudo-color windows, backing store (a means of saving part of the window that's obscured),

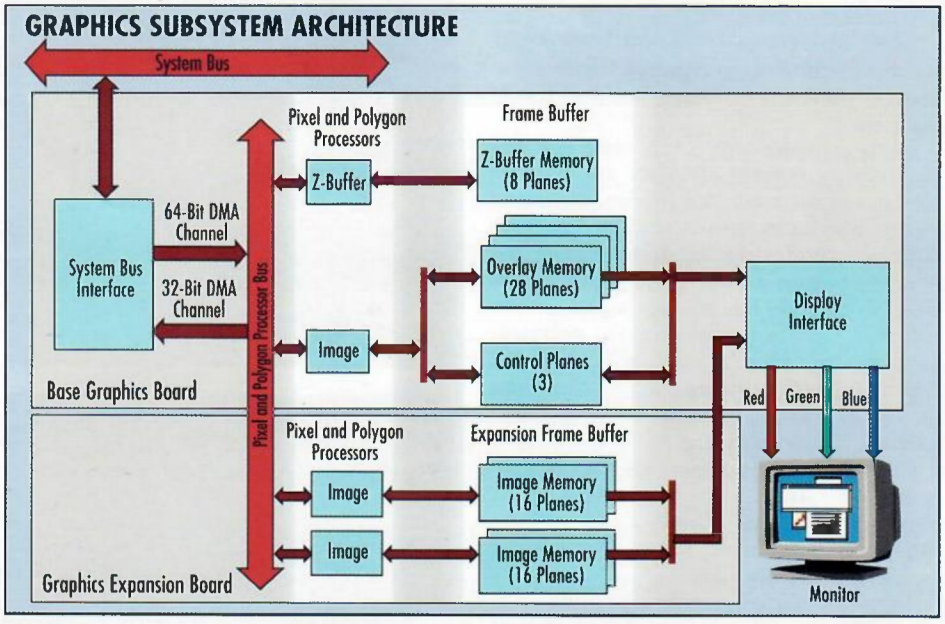


FIGURE 2: *A full graphics subsystem consists of two boards that are tightly coupled to both the CPUs and memory. These boards incorporate rasterizers (pixel and polygon processors), frame buffers, Z buffer, and additional overlay and control planes. The subsystem is coupled to main memory with a 64-bit DMA channel that transfers data from memory to the graphics subsystem and a 32-bit DMA channel that transfers data in the reverse direction.*

overlay graphics, shaded Z-buffer primitives and non-standard input devices.

Applications that use the X windows' *Xlib* will run under X+.

Graphics software, as one might guess, is extremely important to Stardent. The centerpiece of this software is Stardent's Dynamic Object Rendering Environment (Doré) Library, a library of graphics subroutines used to provide dynamic object rendering.

Doré functions at a very high level, allowing applications programmers to concern themselves with high-level, abstract aspects of a scene instead of attending to every detail.

The library includes bindings for C and Fortran source code.

SPEAKING OBJECTIVELY

Doré is object-oriented, hiding the actual data from the application programmer. An object is a collection of data with an object type associated with it. Methods such as delete, print, pick and reference can be used with each object.

While Doré objects can be collected into hierarchies or groups, Doré does not use

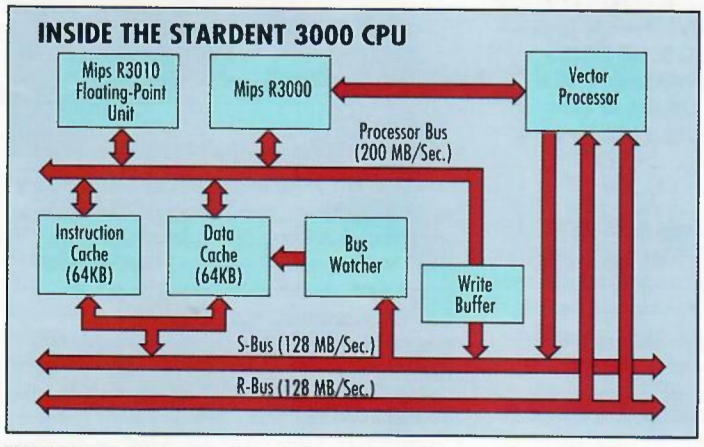


FIGURE 3: *Each Stardent 3000 CPU includes both a scalar and a vector processor. The scalar processor is a Mips R3000 chip running at 32MHz, accompanied by a R3010 floating-point co-processor, and the vector processor is proprietary to Stardent. The scalar processor handles all integer and almost all floating-point scalar operations, and during graphics operations functions as the scene database transverser. There are two independent 64KB direct-mapped caches—instruction and data—and four-deep write buffers. The vector unit performs all vector operations, and during graphics processing serves as the geometry engine.*

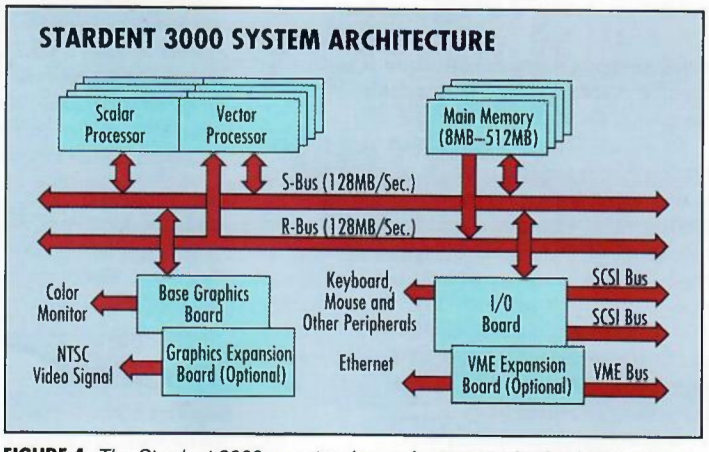


FIGURE 4: *The Stardent 3000 uses two buses for communication between the CPUs, memory, I/O subsystem and graphics subsystem. The buses carry 32-bit addresses and 64-bit data and operate at 16MHz; they are rated at 128MB per second each. The R-bus is dedicated to data transfers from memory to the vector processor and the S-bus handles all other transfers. The system can support a maximum of 512MB of memory.*

message passing or allow "children" objects to inherit their parents' attributes, as do other object-oriented systems.

Doré objects are divided into eight classes: primitives, geometric transformations, attributes, cameras, lights, text, frame and view.

While primitive objects may seem like simple drawing commands, they are actually used to build a scene description, the single copy of which can then be used to draw with different rendering techniques (Fig. 5). Primitive objects include point, marker, line, polyline, triangle list, triangle mesh, simple polygon, simple polygon mesh, polygon, polygon mesh, bilinear patch (e.g., Bezier or Hermite), non-uniform rational B-spline (NURBS) patch, quadric surface (e.g., sphere, cylinder, box), and torus.

Geometric transformations specify geometric operations to be performed on an object or group of objects. They include rotate, translate, scale, shear, look-at-from and matrix transformations.

Atttribute objects modify primitives, cameras and lights. The number of these objects is large; they modify a host of attributes, including color, reflectancy, transparency, field of view, diffuse or ambient lighting, back-face culling (the process of eliminating surfaces that aren't visible) and specularity (the concentrated reflection of light).

The cameras, lights and text classes allow users to control the placement and type of cameras, lights and text.

The frame and view objects are somewhat different from what is found in similar graphics libraries. A view is the result of rendering a set of display groups with a particular camera, set of lights and rendering level. It may be thought of as a single photograph. A frame, however, contains a group of views that are displayed in that frame.

A frame can be displayed on one or more devices. While the frame feature may seem unnecessary, it does provide for an extra measure of device independence; a frame can be viewed on the screen and then output to a printer without changing the objects, view or frame. Multiple frames can then be displayed on a single device simultaneously, if the device is capable of it.

Doré includes two built-in renderers: dynamic and production. A rendering style is associated with a view, not with a frame or device. The dynamic renderer uses the resources of the available hardware to generate images in interactive time—that is, several frames per second. The exact results that are obtained using dynamic rendering may vary from one Stardent model to the next and will likely change over time, according to Stardent.

A Stardent 3000 system that has hardware Gouraud shading will be able to provide such shad-ing at the dynamic level, while systems without such hardware can provide only flat shading.

The production renderer isn't strictly defined either, but currently consists of a constant time ray-tracer that is capable of creating scenes with specularity, environmental reflections and true shadows.

The advantage of defining the rendering styles so loosely is that, over time, as rendering algorithms and rendering hardware improve, Doré applications will take advantage of the advancements without having to make changes to the Doré interface code.

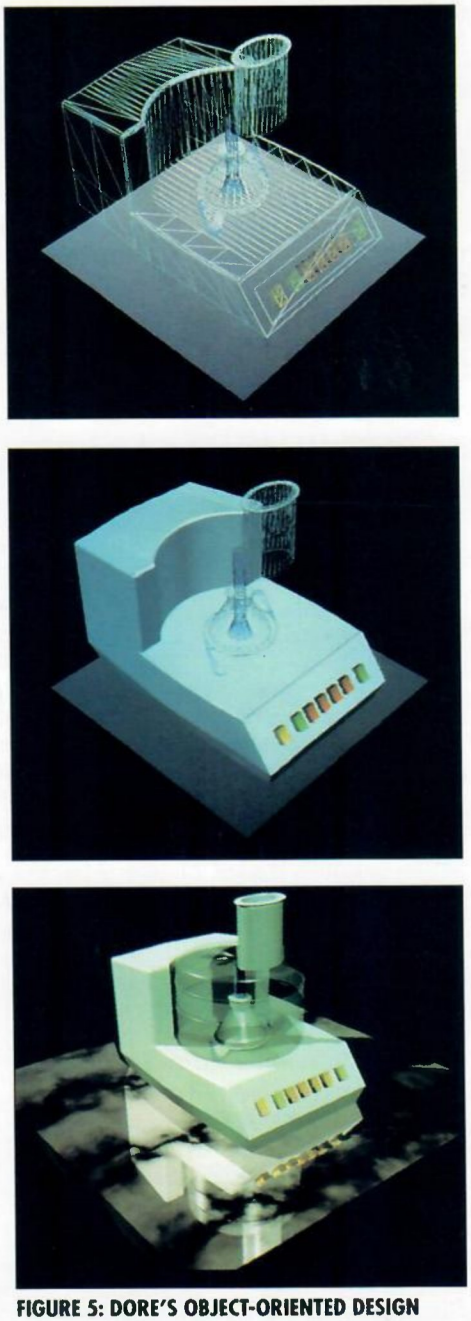


FIGURE 5: DORE'S OBJECT-ORIENTED DESIGN *allows a single scene to be described and then rendered using a variety of methods, for example, wireframe (A), Gouraud shading (B), or a globally shaded image with ray tracing.*

SUPER MINISUPER

The Stardent 3000 is housed in a 22-inch-wide-by-23-inch-deep cabinet that stands 50 inches high (Fig. 6). SCSI or VME expansion can be accomplished via an expansion cabinet whose dimensions and appearance are similar to those of the system cabinet. The 3000 does not require any special cooling equipment and can function in an office environment.

The system enclosure includes a 10-slot backplane, power supply, and room enough for as many as three 5 1/4-inch SCSI disks and one quarter-inch SCSI cartridge tape drive.

Slot 0 in the backplane is used for either an adapter that accepts two 6-by-9-inch VME boards or an expander board that connects to an external VME card cage; slot 1 holds the I/O subsystem board; slots 2 through 7 are used for memory and processor boards and can include a maximum of four boards of either type (at least one board of each type must be installed); slot 8 contains the base graphics board; and slot 9 is for the expansion graphics board.

The minimum-configuration Stardent 3000 Departmental Supercomputer is priced at $69,000 and includes one CPU, 32MB of memory and one 380MB SCSI disk drive. A minimum-configuration Visualization System with the same CPU, memory and drives that is also capable of single-buffered, true-color graphics or double-buffered, pseudo-color graphics is priced at $89,000.

A moderately sized Visualization System, including two CPUs, 64MB of memory, two 760MB disks, the expansion graphics board, a Fortran compiler and NFS, is priced at $176,900. Finally, a high-end, four-CPU server with 256MB of memory, no graphics, Fortran, NFS and three 760MB disk drives is priced at $384,300.

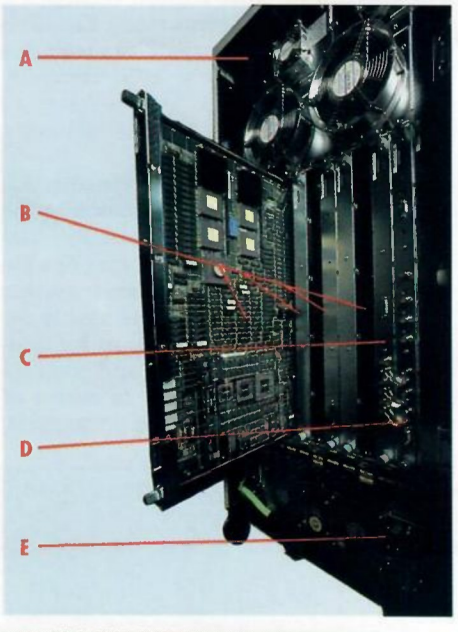


FIGURE 6: THE SYSTEM ENCLOSURE *includes bays (A) for as many as three 5 1/4-inch SCSI disk drives and one quarter-inch SCSI cartridge tape drive. There is also a 10-slot backplane—shown here with four CPU and/or memory boards (B), a graphics subsystem board (C) and an I/O subsystem board (D)—and the power supply (E).*

Although many industry analysts question whether the graphics minisupercomputer market is big enough to sustain the current group of players, innovations from Stardent Computer suggest that this new company's chances of survival are good. Packing one of the fastest CPUs that DR Labs has ever tested, coupled with a powerful graphics environment, the Stardent 3000 is an excellent choice for users running scientific computing applications.

Application Visualization

Included with every Stardent Visualization System is the Stardent Application Visualization System (AVS). AVS is software that, using the facilities of X windows and the Dynamic Object Rendering Environment (Doré) graphics library (previous AVS versions were based on Phigs+), provides a framework so researchers can take advantage of visualization techniques without having a great deal of graphics programming expertise. By taking care of many of the programming details, AVS allows researchers to devote more time to the problem being studied.

AVS combines three-dimensional interactive graphics with supercomputer performance to provide a real-time environment for analyzing and manipulating data from simulations or experiments. It is not intended for programmers; rather, it builds on the resources of graphics libraries to provide a complete environment for data analysis. It goes beyond rendering and viewing manipulations to include data input and transformation.

Because AVS is built on the X Window System, it uses a familiar point-and-click interface. The use of X windows increases AVS' portability.

AVS is designed for the analysis stage of computational simulation. It consists of a Network Editor and an Application Builder, and Image, Volume and Geometry Viewers.

The Network Editor is a tool for designing a visualization application. With the Network Editor, a user builds a network of independent computing components to form a processing network. This network specifies how data should be brought into AVS, how it might be filtered or otherwise manipulated, and how it should be displayed. The range of modules used in a processing network can include data input, filter, mapper and renderer modules. Additional modules, written in C or Fortran, can be added by the user.

Filters are available for applications from fields such as engineering, fluid dynamics and chemistry, and for commonly used formats such as the Brookhaven Protein Databank, Wavefront or MOVIE.BYU. Mapper modules transform data into geometry. Using one of these modules, users can select a visualization technique to apply to the data. Some of the sample mapper modules include isosurfaces of a 3-D field, 2-D slices of a 3-D volume, and 3-D meshes from 2-D elevation data. Renderer modules display geometry, images and volumes. Multiple rendering modules can be used, including a 3-D geometry renderer, image display renderer and several volume renderers.

The Application Builder allows a visualization application to be rapidly prototyped and delivered as a complete application to other users.

The Image and Volume Viewers provide comprehensive image processing and display capabilities, and extend these capabilities into three dimensions. AVS' image processing works with 8- or 24-bit data and floating-point data. Image display features include real-time pan and zoom, and "flipbook" animation. Filtering may be accomplished via table look-up operations to provide contrast stretching, pseudo-color and histogram balancing. Data resizing functions include interpolation, cropping and real-time warping. The three-dimensional image processing features include a real-time isosurface generator, real-time transparent volume renderer, use of geometric objects as slicing surfaces, dot surfaces and vector nets.

The Geometry Viewer allows data to be displayed with various renderings, for example, wireframe, Gourard or Phong shading. AVS supplies 16 independent point, directional or spotlight light sources. Stardent also allows the use of surface properties such as specularity, transparency, real-time texture mapping or anti-aliasing.

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